MKKS gene

McKusick-Kaufman syndrome

Normal Function

The *MKKS* gene provides instructions for making a protein that plays an important role in the formation of the limbs, heart, and reproductive system. The structure of this protein suggests that it may act as a chaperonin, which is a protein that helps fold other proteins. Proteins must be folded into the correct 3-dimensional shape to perform their usual functions in the body. Abnormally folded proteins can also interfere with the functions of normal proteins.

Although the structure of the MKKS protein is similar to that of a chaperonin, some studies have suggested that protein folding may not be this protein's primary function. Within cells, the MKKS protein is associated with structures called centrosomes. Centrosomes play a role in cell division and the assembly of microtubules, which are proteins that transport materials in cells and help the cell maintain its shape. Researchers speculate that the MKKS protein may be involved in transporting other proteins within the cell.

Health Conditions Related to Genetic Changes

Bardet-Biedl syndrome

McKusick-Kaufman syndrome

Two mutations in the *MKKS* gene have been identified in people with McKusick-Kaufman syndrome in the Old Order Amish population. Each of these mutations changes a single protein building block (amino acid) in the MKKS protein. One mutation replaces the amino acid histidine with the amino acid tyrosine at protein position 84 (written as His84Tyr or H84Y). The other mutation replaces the amino acid alanine with the amino acid serine at protein position 242 (written as Ala242Ser or A242S). Affected Amish people have these two mutations in both copies of the *MKKS* gene.

The mutations that underlie McKusick-Kaufman syndrome alter the structure of the MKKS protein. Although the altered protein disrupts the development of several parts of the body before birth, it is unclear how *MKKS* mutations lead to the specific features of this disorder.

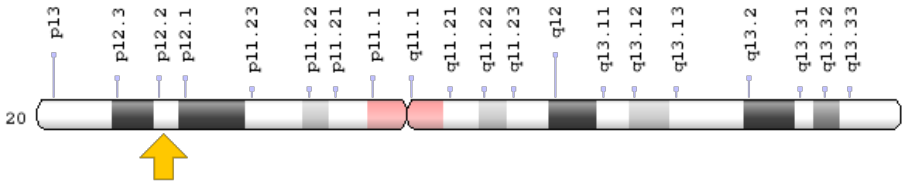
The signs and symptoms of McKusick-Kaufman syndrome overlap significantly with those of another condition called Bardet-Biedl syndrome, which can make the

two conditions difficult to tell apart in infancy and early childhood. Although both syndromes can be caused by changes in the *MKKS* gene, it remains unclear why some mutations cause McKusick-Kaufman syndrome and others cause Bardet-Biedl syndrome.

Chromosomal Location

Cytogenetic Location: 20p12.2, which is the short (p) arm of chromosome 20 at position 12.2

Molecular Location: base pairs 10,404,780 to 10,434,239 on chromosome 20 (Homo sapiens Annotation Release 108, GRCh38.p7) (NCBI)



Credit: Genome Decoration Page/NCBI

Other Names for This Gene

- Bardet-Biedl syndrome 6 protein
- BBS6
- HMCS
- KMS
- MKKS_HUMAN
- MKS

Additional Information & Resources

Educational Resources

- Howard Hughes Medical Institute: First Bardet-Biedl Syndrome Gene Identified (August 28, 2000)
  http://www.hhmi.org/news/first-bardet-biedl-syndrome-gene-identified
- Molecular Cell Biology (fourth edition, 2000): Folding of Proteins in Vivo Is Promoted by Chaperones
  https://www.ncbi.nlm.nih.gov/books/NBK21750/#A553
- The Cell: A Molecular Approach (second edition, 2000): Chaperones and Protein Folding
  https://www.ncbi.nlm.nih.gov/books/NBK9843/#A1200

GeneReviews

- Bardet-Biedl Syndrome
  https://www.ncbi.nlm.nih.gov/books/NBK1363
- McKusick-Kaufman Syndrome
  https://www.ncbi.nlm.nih.gov/books/NBK1502

Scientific Articles on PubMed

- PubMed
  https://www.ncbi.nlm.nih.gov/pubmed?term=%28MKKS%5BTIAB%5D%29+OR+%28BBS6%5BTIAB%5D%29+AND+%28%28Genes%5BMH%5D%29+OR+%28Genetic+Phenomena%5BMH%5D%29%29+AND+english%5Bla%5D+AND+human%5Bmh%5D+AND+%22last+1800+days%22%5Bdp%5D

OMIM

- MKKS GENE
  http://omim.org/entry/604896

Research Resources

- Atlas of Genetics and Cytogenetics in Oncology and Haematology
  http://atlasgeneticsoncology.org/Genes/GC_MKKS.html
- ClinVar
  https://www.ncbi.nlm.nih.gov/clinvar?term=MKKS%5Bgene%5D
- HGNC Gene Family: Bardet-Biedl syndrome associated
  http://www.genenames.org/cgi-bin/genefamilies/set/980
- HGNC Gene Family: Chaperonins
  http://www.genenames.org/cgi-bin/genefamilies/set/587

- HGNC Gene Symbol Report
  http://www.genenames.org/cgi-bin/gene_symbol_report?q=data/hgnc_data.php&hgnc_id=7108
- NCBI Gene
  https://www.ncbi.nlm.nih.gov/gene/8195
- UniProt
  http://www.uniprot.org/uniprot/Q9NPJ1

Sources for This Summary

- Hirayama S, Yamazaki Y, Kitamura A, Oda Y, Morito D, Okawa K, Kimura H, Cyr DM, Kubota H, Nagata K. MKKS is a centrosome-shuttling protein degraded by disease-causing mutations via CHIP-mediated ubiquitination. Mol Biol Cell. 2008 Mar;19(3):899-911. Epub 2007 Dec 19.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/18094050
  Free article on PubMed Central: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2262992/
- Katsanis N, Beales PL, Woods MO, Lewis RA, Green JS, Parfrey PS, Ansley SJ, Davidson WS, Lupski JR. Mutations in MKKS cause obesity, retinal dystrophy and renal malformations associated with Bardet-Biedl syndrome. Nat Genet. 2000 Sep;26(1):67-70.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/10973251
- Kim JC, Ou YY, Badano JL, Esmail MA, Leitch CC, Fiedrich E, Beales PL, Archibald JM, Katsanis N, Rattner JB, Leroux MR. MKKS/BBS6, a divergent chaperonin-like protein linked to the obesity disorder Bardet-Biedl syndrome, is a novel centrosomal component required for cytokinesis. J Cell Sci. 2005 Mar 1;118(Pt 5):1007-20.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/15731008
- Slavotinek AM, Biesecker LG. Unfolding the role of chaperones and chaperonins in human disease. Trends Genet. 2001 Sep;17(9):528-35. Review.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/11525836
- Slavotinek AM, Searby C, Al-Gazali L, Hennekam RC, Schrander-Stumpel C, Orcana-Losa M, Pardo-Reoyo S, Cantani A, Kumar D, Capellini Q, Neri G, Zackai E, Biesecker LG. Mutation analysis of the MKKS gene in McKusick-Kaufman syndrome and selected Bardet-Biedl syndrome patients. Hum Genet. 2002 Jun;110(6):561-7. Epub 2002 May 9.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/12107442
- Slavotinek AM, Stone EM, Mykytyn K, Heckenlively JR, Green JS, Heon E, Musarella MA, Parfrey PS, Sheffield VC, Biesecker LG. Mutations in MKKS cause Bardet-Biedl syndrome. Nat Genet. 2000 Sep;26(1):15-6. Erratum in: Nat Genet 2001 Jun;28(2):193.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/10973238
- Stone DL, Slavotinek A, Bouffard GG, Banerjee-Basu S, Baxevanis AD, Barr M, Biesecker LG. Mutation of a gene encoding a putative chaperonin causes McKusick-Kaufman syndrome. Nat Genet. 2000 May;25(1):79-82.
  Citation on PubMed: https://www.ncbi.nlm.nih.gov/pubmed/10802661

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